Impact of Jatropha curcas (JC) on local food security in Kenya

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Abstract

Jatropha curcas[1] has been introduced in Kenya with the hope that it will provide smallholders an additional income and boost rural development. Yet, high expectations were revised downwards and questions surged about potential negative impacts on food security. Initial research in 3 food insecure case study sites revealed that jatropha is currently not negatively affecting food security as it is only cultivated by food secure farmers who consider it as a venture crop. Nevertheless, as a matter of precaution jatropha should not be planted on plots and instead priority should be given to hedges or food crops in order to avoid negative impacts on food security.

Background and objective

Agriculture plays a key role for global sustainable development as it is a source for food, feed, fuel and fibre and provides a livelihood to about 2.6 billion people (von Braun 2005; WDR 2008; IAASTD 2009). Most of these women, men and children are living in the global South and are engaged in small-scale farming, which provides half of the total food production globally (IAASTD 2009). In the first half of the 21st century, demand for agricultural produce is expected to grow by 70%, thereby increasing the pressure on already scarce natural resources (FAO 2009) and causing major concerns about food security.

In many parts of Sub-Saharan Africa this development takes place in an already food insecure context. Famines are endemic since the late 1960s in several parts of the continent, mostly caused by natural stressors and political crises (Devereux 2000). Kenya is classified by the FAO as being in a protracted crisis, which means that it is experiencing chronic food deficits, disruption

[1] Hereafter referred to as "*jatropha*"

of livelihoods over a prolonged time and the incapability of the state to respond to and mitigate threats to its population (FAO 2010).

Policymakers started promoting biofuels as a way to boost rural development and energy supply based on the expectation that smallholders could participate in the production either in out-grower schemes or as labourers on large-scale plantations. In sub-Saharan Africa much hope was drawn from the introduction of *jatropha*. However, competition between food and energy crops such as *jatropha* for land and water can have significant impacts on food security (HLPE 2011), the environment (Koh et al. 2011) and even lead to conflicts among resource users (Findlater and Kandlikar 2011).

The objective of this paper is thus to assess the past and future impact of *jatropha* production on local food security. This was done by a qualitative evaluation of the food security situation and a characterisation of main food insecurity drivers in three case study sites in Kenya. Additionally, land use and land cover changes of the past 10 years were analysed and related to *jatropha* production as well as overall food security situation. Therewith, the paper discusses positive and negative impacts of *jatropha* production on local food security and identifies challenges and opportunities in order to guide land use planning, inform policy debate and support extension services facing the challenge of integrating biofuel production into existing farming systems

Research Design and Methodology

Project context

Research for this paper was conducted in the ERA-ARD (www.era-ard.org) funded *Bioenergy in Africa* (BIA) project, which was implemented between 2009 and 2011 in East Africa and Central America (www.bioenergyinafrica.net). The aim of this project is to identify potentials and risks of *jatropha* and related crops for the rural poor.

Methods

Fieldwork for the BIA project was conducted in 9 research areas in Ethiopia, Kenya and Tanzania. These areas cover different agro-climatic zones, farming systems and *jatropha* production types, such as large-scale plantations, out-grower schemes with either mono- or intercropping systems, and hedges. Additional research was conducted at national scale in Kenya through 3 MSc theses concentrating on GIS and remote sensing analyses of potential impacts of biofuel. Out of these research activities, 3 major contributions were used for this paper:

1. A household survey was conducted in 2010 by Kenyan MSc students in 3 research areas: Bondo, Kibwezi and Kwale (Figure 1). The focus of this survey was to assess socio-economic potentials and risks of *jatropha* production for smallholders. A questionnaire was used to interview equal numbers of *jatropha* growers and non-growers in each area. Data collected was compiled and analysed with SPSS. In what follows, results from this survey are referred to as "**household survey**" results.
2. An MSc research was conducted to determine drivers and levels of food insecurity at national scale in Kenya. A definition of food insecurity drivers, adapted to the Kenyan context, was developed on the basis of literature and expert interviews. Four food insecurity levels were defined (no, moderate, severe and acute food insecurity) based on the food insecurity severity scale of the Famine Early Warning System Network (FEWS NET, www.fews.net). GIS was used to derive 218 mapping units from administrative units and

agro-climatic zones. Participatory mapping and interviews were conducted with experts dealing with food security matters (district and extension officers) in 19 locations in Kenya to determine, for each mapping unit, the 3 major food insecurity drivers, the food insecurity level, and to gain additional information on food security issues. In what follows, results derived from this work are referred to as "**expert survey**" results.

3. In Bondo and Kibwezi mapping of land cover change over a span of 10 years was done in the frame of an MSc research, through GPS survey and on the basis of Landsat satellite image analysis. Such analysis could not be done for Kwale owing to the unavailability of cloud free satellite images. In all areas, locations of *jatropha* fields and hedges were recorded by GPS.

Research areas

The 3 research areas are located in the western, eastern and coastal regions of Kenya (Figure 1).

Bondo research area lies on the north-eastern side of Lake Victoria and includes parts of Bondo, Rarieda and Madyani Divisions. It is mostly semi-arid but also well-endowed with water resources from rivers that drain into the lake. The local community is predominantly engaged in fishing and mixed subsistence farming, growing mainly sorghum, maize, and cassava, mixed with some livestock, especially dairy goats and poultry. Few farmers have introduced water pans to supplement rain water for crop and livestock production.

Kibwezi research area is in the larger Makueni region, which is part of the eastern semi-arid areas of Kenya, and strands along the Nairobi-Mombasa road. Rainfalls are highly variable and unreliable. The hilly terrain to the north is relatively wet compared to the drier flatlands to the south. Local communities are agro-pastoralists. Main crops include maize, beans, pigeon peas with some isolated areas of sorghum and millet in the lower drier zones. Where conditions allow farmers grow some vegetables and fruits through irrigation along the main seasonal rivers and near water pans. Local breeds of livestock are most prominent.

Kwale research area lies between the Shimba hills and the Kenyan coastline. It is a prime tourist destination because of the coast, Shimba hills National Reserve and the Mwaluganje Elephant Sanctuary. The main sources of livelihood include subsistence fishing and mixed farming, tourism, dairy farming in Shimba Hills, commercial poultry and mining. Main crops in Kwale are cassava, maize and cashew nuts.

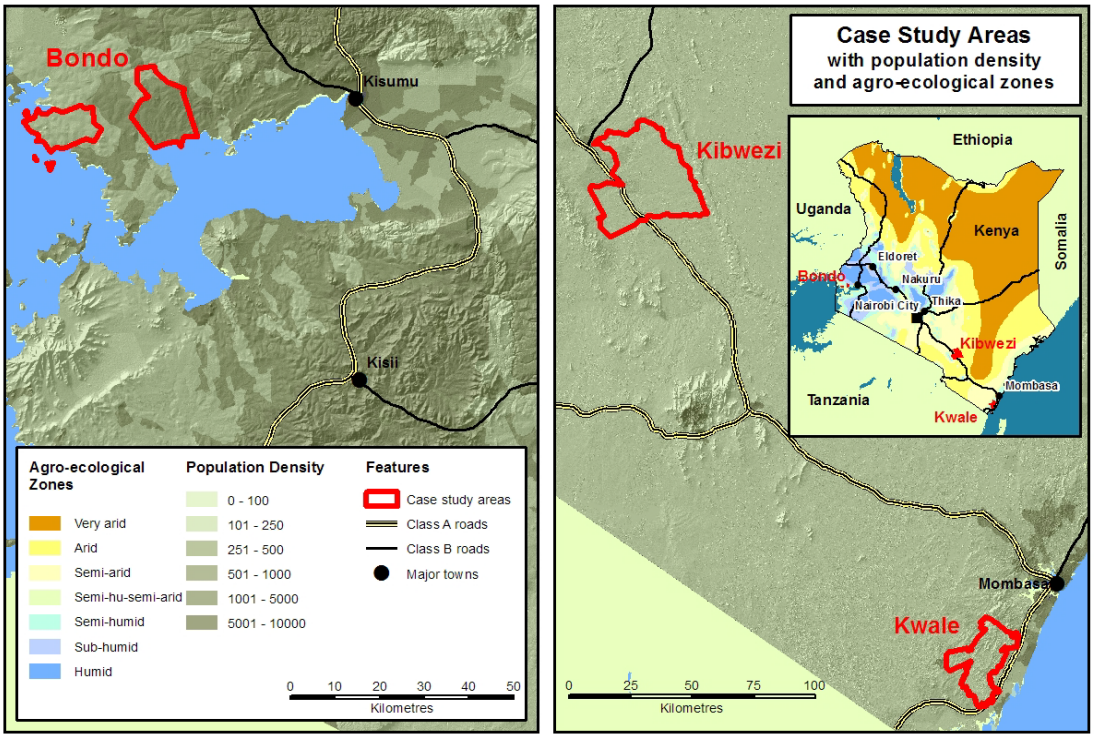

Figure 1: Map of the 3 research areas with population density and agro-ecological zones (map insert).

Status of knowledge

Food security

There are different definitions and concepts of food security. One that is widely accepted and used is the definition from the World Food Summit of 1996, which includes physical, political and socio-economic determinants to procure and consume food: *"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life".*

This definition underlines the multi-dimensionality of food security by addressing the 4 dimensions of availability, access, utilization and stability. Food availability denotes sufficient quantities of food of appropriate quality, supplied either through domestic production or imports (including food aid). Access to food is given when individuals have access to adequate resources for acquiring food for a nutritious diet. When utilization of food is adequate people have an adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being meeting all their physiological needs. Stability refers to the time dimension of food security, whereas a population, household or individual must have access to food at all times and should not lose access to food due to shocks or cyclical events (FAO 2006).

Misselhorn (2006 and 2004) points out that it is important to also look at food security across spatial scales, down to the communities, households and the individuals within the households because food security cannot only be reduced to sufficient global and national food production (Misselhorn 2006 and 2004). This suggests that food security is context-specific and multi-scalar and is not only affected by global and national drivers.

Jatropha

Jatropha is a deciduous shrubby tree from the Euphorbiaceae family originating from Central America, but nowadays found throughout the tropical zone. It produces seeds, which contain about 30% of high-quality oil suited for direct combustion or transesterification. Hence, *jatropha* has attracted attention as a possible source of renewable energy. As it was reported that it is able to grow in semi-arid climates and on poor soils, *jatropha* was also seen as an opportunity to enhance rural smallholders' livelihoods through income generation and the provision of affordable and locally available energy, without threatening food production (Openshaw 2000, Henning 2007, Van Eijck and Romjin 2008, Messemaker 2008, Muok and Kallback 2008).

Since 2005, high economic hopes placed in *jatropha* were revised downwards. Recent research conducted in East Africa has shown that commercial plot based *jatropha* production, is not economically viable for smallholders (GTZ 2009, Findlater and Kandlikar 2011, Feto 2011, Wiggins et al. 2011, Mogaka et al. forthcoming). *Jatropha* has also been strongly criticized, as it is feared that its production will lead to increased pressure on land, competition with food crop production, and more food insecurity (Cotula et al. 2011, FAO 2010, Ehrensperger et al. 2012). Some hope was placed in the production of *jatropha* as a hedge or live fence to protect crops or to corral grazing areas, as opportunity costs of land can be avoided to a great extent with this production type (Mogaka et al. forthcoming). There is, so far, no concluding evidence on the food security risks of increased *jatropha* production.

Impacts of biofuels on food security

The share of biofuels contributing to global final energy consumption was still low at 0.6 per cent in 2009, but production is increasing rapidly. In 2010, about 86 billion litres of ethanol and at least 19 billion litres of biodiesel were produced. Ethanol production grew fivefold between 2000 and 2010, and biodiesel increased more than twentyfold (REN21 2011, Hurni et al 2012)

Several African countries have comparative advantages for producing biofuels, like suitable climate, availability of land and cheap labour. It is therefore likely that this industry will seek to expand its activities in Africa, triggering concerns about an increase of food insecurity. While the rise of commodity prices hampers the access to food especially of landless people and the urban poor, demand for biofuels might also affect food security of land-owning people. The availability of food is threatened if land, water and other productive resources are diverted from food production. Stability of food security is affected by the more volatile food prices caused by the use of food crops for biofuel production and by the increased volatility of fuel prices, which is more strongly transmitted to the agricultural sector in the presence of a biofuel industry (UN-Energy 2007).

The discourse on possible food security impacts of biofuel production is highly polarised (Leopold 2010, Salmi forthcoming), and it is likely that answers have to be context specific and take into consideration existing pressure on land resources, policy frameworks, food production and accessibility issues, as well as other criteria.

Results

Food security in Kenya

Levels of food insecurity

Depending on geographic contexts and time, food security in Kenya varies between secure and acutely insecure, which means that households face nearly complete lack of food, and that starvation and excess mortality are evident. Expert survey results indicate that the western and

central high-potential areas and the coast are generally food secure, while the arid and semi-arid areas (ASALs) in the east and north of the country are generally food insecure. The north is most affected by food insecurity, but there are also areas that are less affected. Inversely, there are areas with severe food insecurity in the south, as for example parts of Makueni (the Kibwezi research area is part of Makueni). Overall, food insecurity affects mainly regions with low population densities, marginal ASALs as well as transition areas with high rainfall variability.

Drivers of food insecurity

Driver Classes	Drivers
Economic	Income, employment, costs of living, food prices, prices of agricultural inputs prices of agricultural products, marketing
Ecological	Rainfall variability and water shortage, soil and terrain
Socio-political	Infrastructure, government policies, extension services, education, health
Socio-cultural	Dependency syndrome, unrest and violent conflicts, attitudes and perceptions, tradition, overpopulation
Land use management and production systems	Agricultural practices, post harvest management, overdependence on one crop, land degradation, management of water resources, human-wildlife conflicts, livestock pests and diseases, crop pests and diseases

Table 1: Drivers of food insecurity in Kenya

Literature review and the expert survey show that drivers leading to food insecurity in Kenya can be associated to economic, ecological, socio-political, socio-cultural, and land use management related factors (Table 1). The most important drivers in the north of the country are either ecological or socio-political, and mainly include rainfall variability, adverse policies or lack of infrastructure. Unrest and violent conflicts as a result of cattle rustling and competition for grazing areas are also important concerns. In the south-eastern ASALs ecological issues (rainfall variability) and land use management (inappropriate agricultural practices and water management) dominate, but there are also economic and socio-cultural issues, mainly lack of access to markets and overpopulation. In the central and western highlands all classes of drivers are represented, but economic (prices of agricultural inputs and marketing) and land use management issues (agricultural practices and overdependence on few crops) seem to dominate. Unrest and violent conflicts, and overpopulation affect food security in the area of the Mau escarpment, which was affected by the 2008 post-election violence.

Food security in Bondo research area

Food security level

The expert survey revealed that the area is characterized by moderate to severe food insecurity. Moderate food insecurity means that households have borderline adequate food access. Severe food insecurity means that they experience highly stressed and critical lack of food access with high and above usual malnutrition. Severity increases towards the lake, as the north-western parts take advantage of relatively higher amounts of rainfall and better market integration with Busia for enhanced food supply during shortfalls. The household survey data confirms the perception of local experts, as households indicated experiencing around 6 months of food shortage every year between 2007 and 2009.

Most important food insecurity drivers

Experts were of the opinion that the most critical issues driving food insecurity in this region are economic, and include low **income** levels, high costs of farm inputs and high food prices. Together with the high poverty levels (65%), these drivers greatly limit food production and economic accessibility in the region. Experts also underlined the problem of **marketing** that has for long affected the fishing enterprise. Because of lack of a well organised market infrastructure and network local fishermen have continuously been exploited by middlemen and consequently fish has always fetched low prices. Poor transportation systems and lack of appropriate transport facilities make it difficult for the farmers to take their catch to markets with better price offers.

Water management ranked second as a food insecurity driver during the expert survey. There is very little irrigation taking place thereby leaving a huge water potential untapped. Experts pointed to overreliance on rain-fed agriculture, and poor water management practices as largely responsible for the failure to realise full irrigation potential in the area. Finally, low **soil fertility** and high evaporation rate were noted to be responsible for low land productivity in the area, a situation worsened by poor land management practices.

Other drivers identified by local experts include: (a) institutional and political issues, for example poor devolution of decision-making at the local level due to the negative influence of the council of elders popularly known as "*mbunge ya wananchi*", poor extension services and uncoordinated food security programmes; (b) HIV/AIDS prevalence and waterborne diseases; (c) livestock pests and diseases, and lack of pasture (reasons not specified); (d) lack of crop diversification, absence of commercial farming, dependence on traditional methods and weed menace; and (e) negative attitudes of youth, who often over-rely on the aged for important decisions that affect food production, and are not interested in on-farm activities.

At the household level, adverse weather conditions featured prominently with 71%, 58%, and 54% (N=69) associating it with the food shortages experienced in 2009, 2008 and 2007 respectively. The household survey further revealed other factors, such as poor seed quality (4%) in 2009 and 2008, and post-election violence (12%) in 2008 that were responsible for food insecurity in the area.

Food insecurity coping strategies

Households mentioned the following main coping strategies: i) migration (23%), ii) food aid (28%), iii) sale of assets (61%), iv) borrowing (7%), v) gifts (3%) and vi) other means (25%).

Land use change and jatropha production

By 2000, land use in the Bondo research area was divided into 3 major blocks, with mainly sorghum being grown in the southern headland reaching into Lake Victoria, a dominance of cassava in the middle section and along the lake shore towards the east, and a dominance of maize in the northern part. In 2010 these 3 blocks were largely preserved, with the exception of the southern headland where major parts of the former sorghum farms, along the lake shore were converted into small scale horticultural production. Local experts reported that there is still quite some idle or extensively used land in the region. The visual interpretation of satellite images did not allow to confirm or to infirm this statement.

Jatropha started appearing in the area around and after 2006 mainly in the northern half of the case study area, in the maize and cassava regions (Figure 2). A visual interpretation using Google Earth (Figure 3) showed that *jatropha* plots were established exclusively on existing farmland. Extract "A" shows GPS corner points of a *jatropha* plots established near the lake shore

in a heavily degraded area. Extract “B” shows *jatropha* plots with both mono- and intercropping and *jatropha* hedges in the northern part of the area dominated by maize farming.

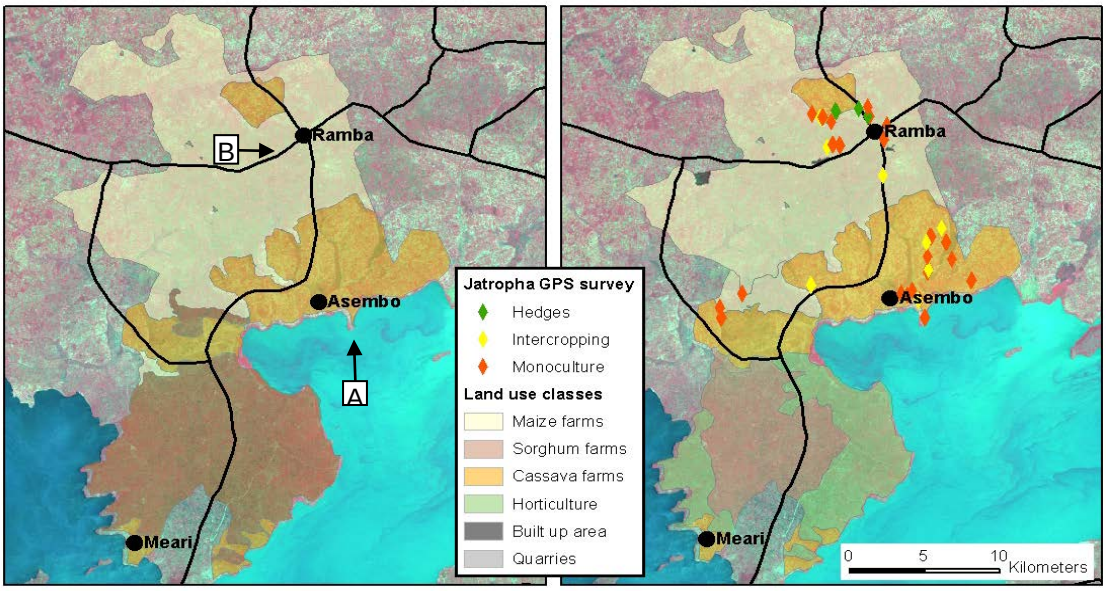

Figure 2: Land use in the Bondo research area in 2000 (left) and 2010 (right). Arrows and white squares with A and B labels are showing the locations of the extracts A and B of Figure 3 below.

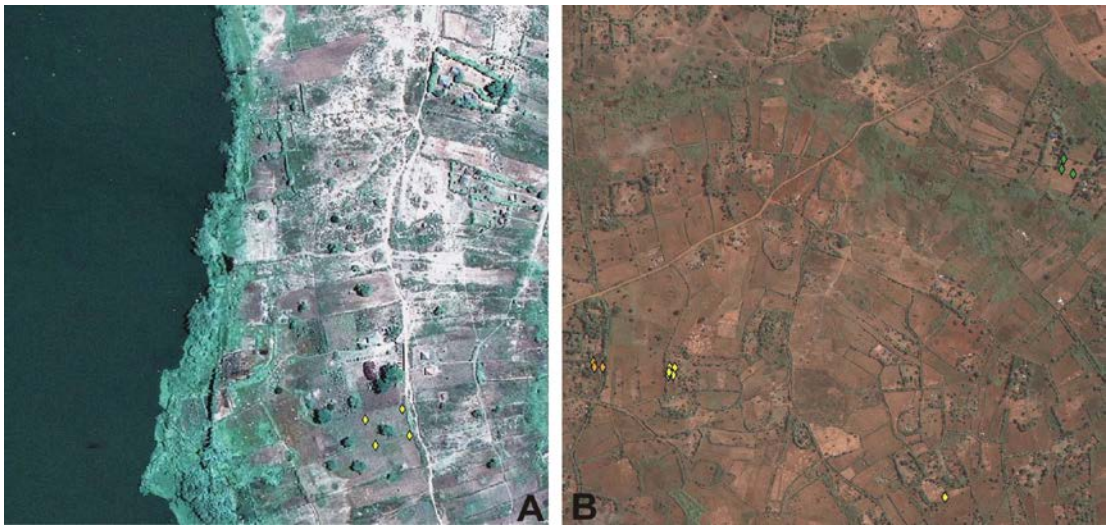

Figure 3: Detailed views of 2 extracts of the Bondo research area with locations of jatropha fields and hedges.

Food security in Kibwezi research area

Food security level

Local experts classified the area as experiencing “severe to acute food insecurity”, meaning that households are either experiencing highly stressed lack of food access, or even face nearly complete lack of food and other basic needs. This assessment agrees well with the household survey results that revealed an increasingly worsening food insecurity situation in the area: in

average 9 months, 10 months and 11 months of food shortage were reported for 2007, 2008 and 2009 respectively, which is underlining the severity of the problem.

Most important food insecurity drivers

Agricultural practices were identified as the major food insecurity driver by local experts, who said that smallholder agro-pastoralists do not plant drought tolerant crops like sorghum and millet, mainly because of labour requirement, especially to scare away birds, which are said to be a serious menace during the last maturing stage of these crops. The efforts by local extension service to re-brand such crops from the negative connotation “orphaned” crops to more positive “high value traditional” crops is expected to reverse this negative attitude towards millet and sorghum. In the western part of the area **human-wildlife conflicts** were reported to have the potential to create food insecurity during otherwise food secure seasons. Frequent crop raids and destruction, especially by elephants and monkeys straying from the open ranches in the neighbouring Kajiado area are the main problems.

Rainfall variability and water shortage were identified by local experts as a driver that affects mostly the regions at lower altitudes. Lack of reliable alternative water sources to support crop growth to maturity adds to the problem. This aspect is emphasised in the household survey with over 90% of the respondents (N=109) attributing the persistent food shortages between 2007 and 2009 to unfavourable weather conditions. Experts underlined the chronic problem of drastic and frequent review of **prices for agricultural inputs**, such as certified seeds and fertiliser, which sometimes may increase by over 50% within a span of less than a year. This is in the backdrop of highly volatile and unstable prices of farm products also mentioned by the respondents, and which, although not underlined as priority issue causing food insecurity in the area, would certainly make agriculture a non-attractive enterprise for farmers to engage in.

Post-harvest management may manifest in different dimensions. According to local experts the main problem touches on storage and preservation of harvested crops. They underlined the problem of long grain borer and afflatoxin, which have become severe in the recent past. This can be attributed to poor storage facilities and lack or appropriate use of crop protection products. Finally, experts mentioned **unrest and violent conflicts**, especially in the upper part of the research area, which neighbours pastoral communities of the Kajiado County to the west. The two neighbourhoods are characterized by seasonal conflicts stemming from competition for pasture and water especially during extended dry spells, when the pastoral communities migrate to the area in search of pasture and allow their cattle to graze in crop fields, which they consider also as part of their pasture.

Other issues affecting food security as highlighted during the expert survey include poverty, low income levels, dependency on relief food from humanitarian agencies, poor market integration, land degradation associated with activities such as charcoal burning, and poor soils.

Food insecurity coping strategies

Main coping strategies mentioned by households are: i) migration (4%), ii) food aid (52%), iii) sale of assets (79%), iv) borrowing (2%), v) gifts (4%) and vi) other means (20%).

Land use change and jatropha production

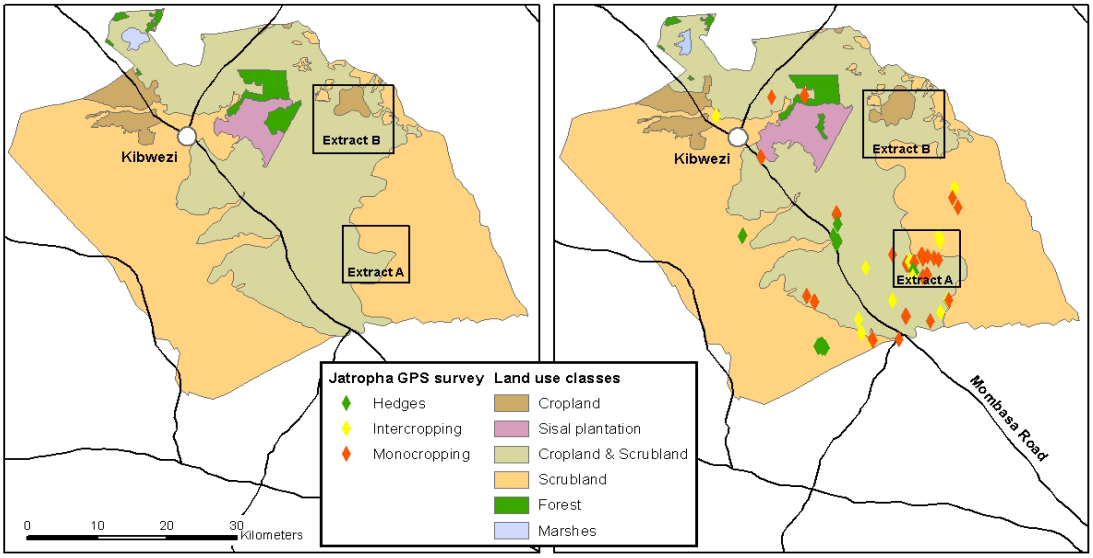

Figure 4: Broad land cover classes in Kibwezi research area in 2000 and 2010

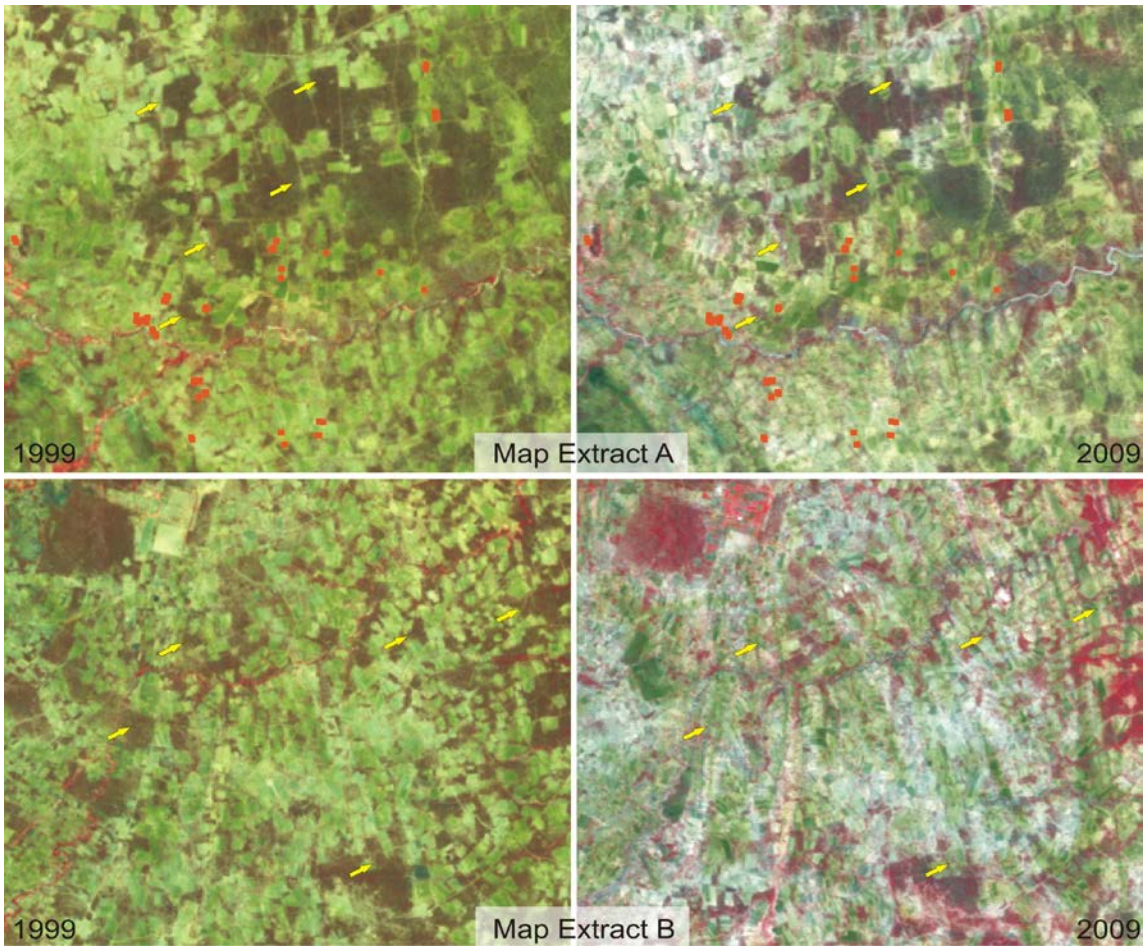

Figure 5: Pressure on scrub- and bushland in Kibwezi; in areas with concentrations of jatropha plots (top) and in areas with no jatropha plots (bottom). Arrows show spots with clearly visible changes of the land cover. Red dots represent locations of jatropha plots (GPS survey).

In 2000 land use in the Kibwezi research area was characterised by a dominance of scrubland, and a cropland-scrubland composite, especially towards the south of the area (Figure 4). Around Kibwezi town other uses are found: to the north-west large areas of more intensive farmland dominate; in the immediate vicinity of the town, towards the east, a sisal plantation of 50 km^2 was established, bordering two forest blocks totalling 40 km^2. This rough spatial structure of land cover classes did not change much by 2010. In the northern part of the area, the loss of 1000 ha of forest and an increase of 2000 ha of the sisal plantation are the most obvious changes. Shifts between scrubland and the cropland-scrubland composite, east of the Mombasa road, could be caused by seasonal variations in biomass between both images. Jatropha farms were established mainly in the south of the area, in the cropland-scrubland composite.

Figure 5 shows two extracts of the land use map; one (extract A) in an area with numerous jatropha plots and another (extract B) in an area with no jatropha plots. These images show that in both areas land use intensity increased over the 10 years period, independently from the vicinity of *jatropha* farming. This is seen in the disappearance of bush and shrub land (dark green colours) and in the increase of crop or grazing areas (light green colours). The yellow arrows point to spots with obvious changes of land cover.

Food security in Kwale research area

Food security level

The expert survey placed the region at moderate food insecurity level, which agrees with the 2007 – 2009 trends established through the household survey of 3 months in 2007, and 4 months in 2008 and 2009 of food shortage.

Most important food insecurity drivers

The expert survey revealed three broad clusters of drivers of food insecurity, namely agricultural practices, human-wildlife conflicts, and attitudes and perceptions in order of significance, and which we briefly elaborate here below.

Agricultural practices: According to local experts, people's attitude and culture to remain in subsistence farming, despite the availability of land with the potential to support commercial farming, is the main cause of food insecurity in the area. They argued that subsistence farming leads people to think that as long as the harvest of one season can take them to the next they don't feel that it is necessary to engage in other farm-based enterprises.

The proximity of the area to 2 wildlife habitats (Shimba Hills National Reserve and the Mwaluganje Elephant Sanctuary) makes the communities in the adjacent areas vulnerable to **human-wildlife conflicts**. Although local experts did not elaborate on the nature and extent of damage resulting from such conflicts, available literature, based on similar studies shows evidence of situations where crop raids by wildlife have reduced food secure regions to total insecurity. The present case study is no exception.

Local experts revealed that because of peoples' **attitude and perception** there is unexplained resentment on the use of farm chemicals (crop protection products and fertilisers), to the extent that most farmers sell free supplies from extension agents instead of using them in their own farms. This contributes to reduce land productivity, hence enhancing food insecurity in the affected areas.

Other food insecurity drivers highlighted in this case study touch on tourism, poor market integration (affecting food re-distribution), and high costs of food production leading to high food

prices thus making it economically inaccessible by most poor farmers. Tourism was in particular said to distort food commodity prices by creating very high demand that tends to push the prices beyond the financial capabilities of the common farmer.

Contrastingly, the household survey established different although related factors, chiefly unfavourable weather conditions (30%), poor seed quality (4%), lack of land (5%), and introduction of bioenergy crops like Jatropha, starting from 2008 (2%). Others are shortage of farm labour, and the post-election violence of 2007 and 2008.

Food insecurity coping strategies

Main coping strategies reported by households are: i) migration (8%), ii) food aid (45%), iii) sale of assets (33%), iv) borrowing (2%), v) gifts (1%) and vi) other means (20%).

Discussion

Impacts of jatropha on food security

Jatropha was introduced in a context of generalised intensification of land use in the 3 case study areas. However, there is no indication, neither from local experts, nor from the households themselves, nor from the spatial analysis of its development, that *jatropha* production has played a significant role in accelerating this intensification process, or that it has influenced food security in the research areas by increasing pressure on land and other productive resources. It can therefore be stated, that currently, *jatropha* is not negatively affecting food security as production is still at a very low level and only cultivated by food secure farmers, who are ready to venture into a risky energy crop production (Mogaka et al. forthcoming).

Improving food security in the 3 research areas

Strategies for improved food security vary depending on the drivers identified in each research area. In Bondo a better market integration (through better infrastructure), the improvement of water management, in particular a better utilisation of irrigation potential, are high priority areas of intervention. In Kibwezi the focus should be on improving agricultural practices, especially the reintroduction of drought tolerant crops like millet and sorghum, post harvest management, improving wildlife management in the neighbouring Kajiado area, and the formation of cooperatives for the purchase of agricultural inputs and better market integration. In Kwale food security strategies should include the improvement of market integration of agriculture, and the formation of cooperatives to achieve fair prices on the market. Other issues are sustainable utilisation of agricultural inputs to improve production, and better wildlife management in the protected areas.

Conclusions

Commercial pressure on land in Kenya is growing, as exemplified by the increasing size of sisal plantation in Kibwezi. Consequently, prices for agricultural land are also increasing in many parts of the country. Hence, activities that tend to further increase this trend as for example biofuel production, have to be promoted with great care and after careful assessment of local conditions in the targeted contexts.

In the case of *jatropha*, this means that hedge production should be favoured over plot based production. However, an additional problem is lack of information, which was also highlighted by local experts. Extension officers have not been briefed on *jatropha* and are therefore unable to advise farmers properly. As the economic viability of this energy crop is also uncertain, many

farmers do not see it as a real opportunity. The recent discovery of important oil fields in the north of Kenya (Daily Nation newspapers of March 2012) might represent a new ball game altogether and postpone further investment into biofuels to a distant future.

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